## TOTAL NEW HIV INFECTIONS IN GABON: A BOX-JENKINS ARIMA APPROACH

## Dr. Smartson. P. NYONI<sup>1</sup>

<sup>1</sup>ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

#### Mr. Thabani NYONI<sup>2</sup>

<sup>2</sup>Department of Economics, University of Zimbabwe, Harare, Zimbabwe

# **ABSTRACT**

Using annual time series data on the total number of new HIV infections in Gabon from 1990 - 2018, the study makes predictions for the period 2019 - 2030. The paper employs the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, H, the series under consideration is an I (1) variable. Based on the AIC, the study presents the ARIMA (1, 1, 0) model as the parsimonious model. The diagnostic tests further reveal that the presented model is very stable and its residuals are not serially correlated. The results of the study indicate that the total number of new HIV infections in Gabon is likely to continue declining over the out-of-sample period.

#### 1.0 INTRODUCTION

Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (ADIS) is a major public health concern, especially in Africa, particularly sub-Saharan Africa, where 70% of the 33 million people estimated to be infected by HIV in 2009 reside. Between 2002 and 2020, 68 million people will die of AIDS in the 45 countries most affected (UNAIDS, 2010). Gabon is still in the range of countries where the prevalence rate is worrisome (Christiane *et al.*, 2014). In fact, HIV prevalence in Gabon is approximately 5.9% (Okome-Nkoumou *et al.*, 2014). The main goal of this study is to predict the number of new HIV infections in Gabon over the period 2019 – 2030. This piece of work will go a long way in examining the possibility of ending the HIV scourge in the country.

### 2.0 LITERATURE REVIEW

Okome-Nkoumu *et al.* (2014) established an epidemiologic profile of opportunistic diseases 10 years after the introduction of HAART in Gabon in 458 patients. The study found out that the prevalence of opportunistic diseases in Gabon remains high. Christiane *et al.* (2014) assessed HIV-related knowledge, attitudes and practices (KAPs) of high school and college students in Libreville, Gabon. The study showed that students in Gabon have inadequate information about HIV/AIDS transmission and prevention. This could be the reason why it remains difficult to win the war against the HIV epidemic in Gabon. In a review paper, Boukandou *et al.* (2018) analyzed traditional plants that have reported anti-HIV activity. The study found out that in Gabon, indeed, there are proven anti-HIV traditional plants and that could explain why locals in the country are interested in medicinal plants for the treatment of AIDS related infections. No similar study has been done in Gabon. Our paper will be the first study to model and forecast new HIV infections in the country.

### 3.0 METHODODOLOGY

### 3.1 The Box – Jenkins (1970) Methodology

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018c). This approach will be used to analyze, H, the series under consideration.

### 3.2 The Applied Box – Jenkins ARIMA Model Specification

If the sequence  $\Delta^d H_t$  satisfies an ARMA (p, q) process; then the sequence of  $H_t$  also satisfies the ARIMA (p, q) process such that:

where  $\Delta$  is the difference operator, vector  $\beta \in \mathbb{R}^p$  and  $\alpha \in \mathbb{R}^q$ .

## 3.3 Data Collection

This study is based on annual observations (that is, from 1990 - 2018) on the total number of new HIV infections, that is, adults (ages 15+) and children (ages 0 - 14) [denoted as H] in Gabon. Out-of-sample forecasts will cover the period 2019 - 2030. All the data was collected from the World Bank online database.

# 3.4 Diagnostic Tests & Model Evaluation

#### 3.4.1 The ADF Test in Levels

Table 1: without trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
Н	-1.098593	0.2396	-2.653401	@1%	Non-stationary
			-2.653401	@5%	Non-stationary
			-1.609571	@10%	Non-stationary

Table 1 shows that H is not stationary in levels.

## 3.4.2 The ADF Test (at First Differences)

Table 2: without trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion	
ΔΗ	-2.074621	0.0386	-2.653401	@1%	Non-stationary	
		-1.953858	@5%	Stationary		
			-1.609571	@10%	Stationary	

Table 2 indicates that H is an I (1) variable.

# 3.4.3 Evaluation of ARIMA models (without a constant)

Table 3: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 1, 1)	343.7877	0.37997	-3.2592	119.4	2.9133
ARIMA (1, 1, 0)	341.9814	0.38334	-1.1283	119.51	2.9397
ARIMA (0, 1, 1)	359.9840	0.63349	15.502	148.13	4.4224
ARIMA (2, 1, 0)	343.7680	0.37978	-3.3294	119.38	2.9158

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (1, 1, 0) model is finally selected.

## 3.5 Residual & Stability Tests

# 3.5.1 Correlogram of the Residuals of the ARIMA (1, 1, 0) Model

Figure 1: Correlogram of the Residuals

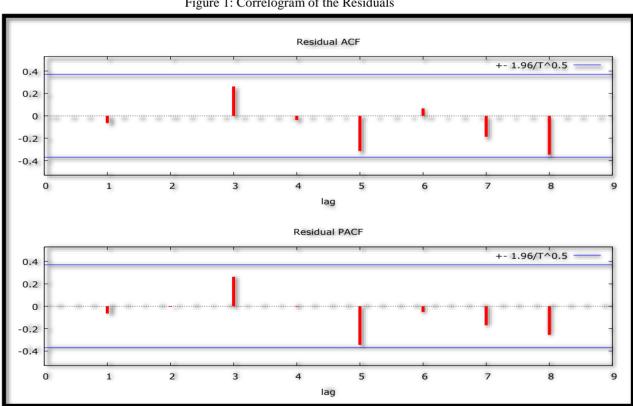
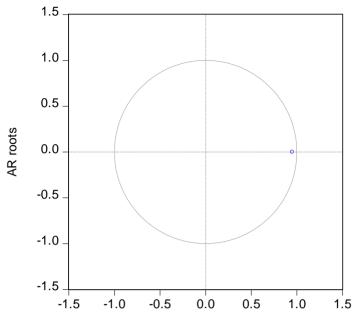


Figure 1 indicates that the estimated optimal model is adequate since ACF and PACF lags are quite short and within the bands.

# 3.5.2 Stability Test of the ARIMA (1, 1, 0) Model

Figure 2: Inverse Roots

# Inverse Roots of AR/MA Polynomial(s)



Given that the AR root lies inside the unit circle, it implies that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (1, 1, 0) model is stable.

# 4.0 FINDINGS OF THE STUDY

# 4.1 Results Presentation<sup>1</sup>

Table 4: Main Results

ARIMA (1, 1, 0) Model:					
The chosen optimal model, the ARIMA (1, 1, 0) model can be expressed as follows:					
$\Delta H_t = 0.902275 \Delta H_{t-1} \dots [2]$					
Variable Coefficient Standard Error z p-value					
$eta_1$	0.902275	0.0915162	9.859	0.0000***	

Table 9 shows the main results of the ARIMA (1, 1, 0) model.

## Forecast Graph

Figure 3: Forecast Graph – In & Out-of-Sample Forecasts

Volume 3, Issue X, October 2020 | 3

<sup>&</sup>lt;sup>1</sup> The \*, \*\* and \*\*\* imply statistical significance at 10%, 5% and 1% levels of significance; respectively.

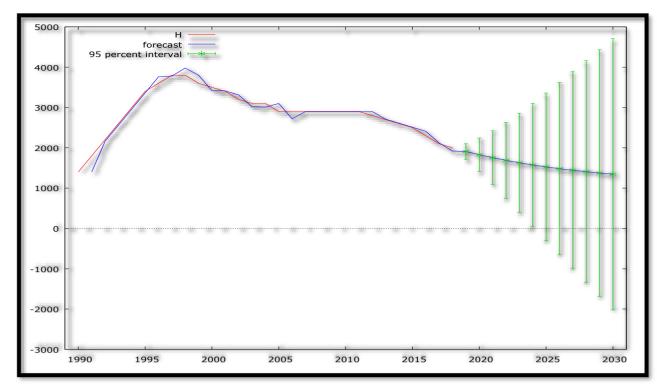


Figure 3 shows the in-and-out-of-sample forecasts of the H series. The out-of-sample forecasts cover the period 2019 - 2030.

# Predicted H-Out-of-Sample Forecasts Only

Table 5: Predicted H

Year	Predicted H	Standard Error	95% Confidence Interval
2019	1909.77	98.1402	(1717.42, 2102.12)
2020	1828.36	210.914	(1414.98, 2241.75)
2021	1754.91	339.930	(1088.66, 2421.16)
2022	1688.63	479.847	(748.150, 2629.11)
2023	1628.83	627.089	(399.761, 2857.90)
2024	1574.88	779.140	(47.7917, 3101.96)
2025	1526.19	934.158	(-304.721, 3357.11)
2026	1482.27	1090.77	(-655.593, 3620.13)
2027	1442.64	1247.92	(-1003.24, 3888.51)
2028	1406.88	1404.81	(-1346.51, 4160.26)
2029	1374.61	1560.84	(-1684.58, 4433.80)
2030	1345.50	1715.52	(-2016.86, 4707.86)

Figure 4: Graphical Analysis of Out-of-Sample Forecasts

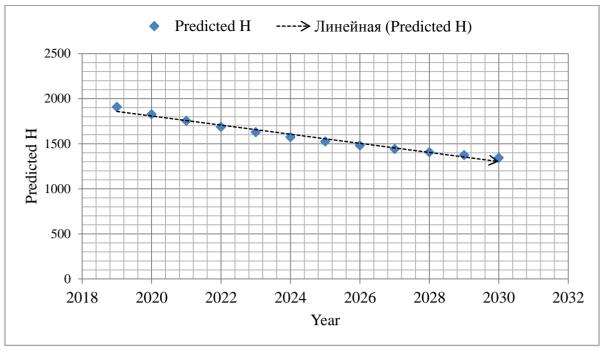


Table 5 and figure 4 show the out-of-sample forecasts only. The total number of new HIV infections in Gabon is forecasted to decline gradually from the estimated 1910 new infections in 2019 to approximately 1346 new infections by 2030.

#### 5.0 CONCLUSION

The study shows that the ARIMA (1, 1, 0) model is not only stable but also the most suitable model to forecast the total annual of new HIV infections in Gabon over the period 2019 – 2030. The model predicts a commendable decrease in the total annual number of new HIV infections in Gabon. The paper recommends that the government of Gabon should continue scaling up HIV prevention and treatment access. In this regard, ambulatory treatment centers are recommendable and should continue being operationalized. Special emphasis should to be directed towards behavior change interventions such as increased condom use as well as reduction of sexual partners. Gabon being a well-known low circumcision country; should continue up scaling voluntary medical male circumcision as an additional HIV prevention strategy.

### REFERENCES

- [1] Boukandou, M. M. M., *et al.* (2018). Review of Gabonese Traditional Plants That Have Reported Anti-HIV Activity, *Indian Journal of Traditional Knowledge*, 17 (3): 414 424.
- [2] Christiane, N. A., *et al.* (2014). HIV/AIDS Prevalence, Knowledge, Attitudes and Related Behaviours Among Young People in Libreville, Gabon, *IOSR Journal of Humanities and Social Science*, 19 (1): 59 65.
- [3] Nyoni, T (2018b). Modeling and Forecasting Inflation in Kenya: Recent Insights from ARIMA and GARCH analysis, *Dimorian Review*, 5 (6): 16 40.
- [4] Nyoni, T. (2018a). Modeling and Forecasting Naira/USD Exchange Rate in Nigeria: A Box-Jenkins ARIMA Approach, MPRA Paper No. 88622, *University Library of Munich*, Munich, Germany.
- [5] Nyoni, T. (2018c). Box Jenkins ARIMA Approach to Predicting net FDI inflows in Zimbabwe, MPRA Paper No. 87737, *University Library of Munich*, Munich, Germany.
- [6] Okome-Nkoumou *et al.* (2014). Opportunistic Diseases in HIV-related Patients in Gabon Following the Administration of Highly Active Antiretroviral Therapy: A Retrospective Study, *American Journal of Tropical Medicine & Hygiene*, 90 (2): 211 215.
- [7] UNAIDS (2010). Global AIDS Epidemic, UNAIDS, New York.